

10/511070

Attorney Docket No. BR8809

Int'l Patent Appln. No. PCT/EP03/03650  
SUBSTITUTE SPECIFICATION

DT04 Rec'd PCT/PTO 12 OCT 2004

## BLIND RIVET

### Background of the Invention

5 [0001] The present invention relates to an improved blind rivet, more particularly to a peel-type blind rivet which is particularly suitable for anchoring in relatively soft materials such as wood or plastics.

10 [0002] Conventional blind riveting techniques which are normally used to secure together two or more workpieces, utilise a blind rivet having a tubular shank with an enlarged head at the operative end thereof such that the shank can pass through a preformed hole in extending between two workpieces, whereby a mandrel disposed within the tubular rivet body having an enlarged head is then used to compress the rivet body on the blind side (ie. behind the workpieces to be set) to create a bulge which will compress the workpieces 15 against the enlarged head.

20 [0003] However, where the blind side workpiece material is both of substantial thickness and is relatively soft, modified peel-type blind rivets have been employed which operate in a significantly different manner whereby the end of the rivet body, remote from the head (the blind side), is caused to split and form into a series of radially extending legs which compress and engage with the soft material into which the peel-type blind rivet has been displaced, whereby these legs are restrained remote from the head-end of the rivet, once set, by providing appropriate means to arrest continued splitting or deformation of such legs. Existing peel-type blind rivets are divided into two distinct groups, the first of which has its 25 body provided with a weakened region which will either be cut to form the required legs by cutting edges formed on the mandrel head, or have preformed, weakened zones (such as channels) within the rivet body along which the body will rupture when the mandrel head is

drawn into the rivet body. These type of rivets normally employ a dual thickness rivet body whereby the weakened regions are of a reduced thickness as compared to the main rivet body such that continued splitting of the rivet is arrested when the mandrel head engages with the thickened portion of the rivet body. Blind rivets of this type are discussed in EP344,005 and  
5 EP328,314.

[0004] An alternative preferred form of peel-type blind rivet employs the use of preformed slots formed in the remote end (opposed to the rivet head) of the rivet body, which slots define the legs to be displaced during the setting operation. One example of a peel-type  
10 blind rivet of this type is disclosed in the applicants earlier British Patent No. GB 2332722.

[0005] However, all of these existing types of peel-type blind rivet require an inclined shoulder formed between the mandrel head and the mandrel shank to engage with and deform the legs outwardly of the rivet, which requires precision engineering in the  
15 formation of such rivet mandrels while the inclined nature of such shoulders result in the legs becoming deformed and caused to curve or bend while being displaced into a set position, such curvature providing less resistance to an applied load, and thereby reducing the strength of the rivet set.

20 [0006] It is therefore an object of the present invention is to alleviate some of the aforementioned problems of existing peel type blind rivets and to provide an improved peel-type blind rivet.

Summary of the Present Invention

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[0007] According to the present invention there is now provided a peel-type blind rivet assembly for setting in relatively soft material, this rivet assembly comprising:

an elongate tubular body having a shank disposed about a shank axis and a preformed head at a first end thereof and an expandable portion at the opposed end of the shank, remote from the head and formed by a plurality of slots, which slots terminate remote from the first 5 end;

a mandrel having a stem extending through and co-axial with the tubular body, which mandrel further having a head having a maximum external diameter greater than the internal diameter of the body; wherein,

the mandrel head forms a shoulder between a mandrel stem and an outer surface of the 10 mandrel head which extends perpendicular to the shank axis.

[0008] Usually, the opposed end of the shank will present a flat surface, perpendicular to the shank axis, for the mandrel shoulder to fit flush therewith.

15 [0009] Preferably, at least one of the plurality of slots increases in width as it extends from an outer surface to an inner surface of the body such that, in cross section, this slot is seen to taper towards the outer periphery of the rivet body. It is possible that the side walls of this at least one slot will be curved, preferably so as to be convex.

20 [0010] Usually each of the plurality of slots will be equally spaced about the circumference of the tubular body so that the angular displacement between adjacent slots about the shank axis is constant.

25 [0011] Preferably, the rivet body will comprise three slots disposed substantially at 120° intervals relative to the shank axis.

[0012] In addition, it is preferred that an inner end of at least one of the plurality of slots is axially inclined so that at least one slot is longer adjacent to the inner surface of the body than adjacent the outer surface of the body.

5 [0013] Usually, the wall thickness of the body will be constant along its axial length and will also have a constant external diameter along such axial length.

10 [0014] In addition, it is preferred that the mandrel stem will have a reduced diameter section adjacent to the shoulder to form a recess within the mandrel stem so that material displaced from the rivet body during the setting operation may be deformed into this recess to restrain the set mandrel head following the setting operation of the rivet.

15 [0015] It is preferred that the maximum diameter of the mandrel head is equal to the external diameter of the shank so that the preformed hole into which the rivet is to be inserted need only be sufficient to receive the diameter of the rivet shank.

Brief Description of the Accompanying Drawings

20 [0016] There will now be described, by way of example only, a preferred embodiment of the present invention with reference to the accompanying illustrative drawings in which:

FIG. 1 shows a partial cross sectional view of a peel-type blind rivet according to the prior art;

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FIG. 1a is an end view of the rivet body of FIG. 1;

FIG. 2 is a partial cross section of the rivet of FIG. 1 shown in a set position;

FIG. 3 shows a partial cross section of a peel type blind rivet according to the present invention;

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FIG. 4 is a plan view from one end of the body of the blind rivet of FIG. 3;

FIG. 5 shows the peel-type blind rivet of FIG. 3 in a set configuration;

10 FIG. 6 is a plan view of the shank of a peel-type blind rivet according to a second embodiment of the present invention;

FIG. 7a shows a plan view from one end of a punch tool used to form the body of the blind rivet of FIG. 3;

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FIG. 7b is a side view of the punch tool of FIG. 7a when viewed along the arrow X; and

FIG. 7c is a side view of an alternative embodiment of the punch tool of FIG. 7a.

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Detailed Description of the Preferred Embodiment

[0017] A peel-type blind rivet assembly (10), according to the prior art, is seen in FIG. 1. This blind rivet assembly (10) comprises a tubular body (2) containing a mandrel (4), and having a head (8) formed by a flattened flange portion, presenting a circumferential shoulder (9) for engagement with a first workpiece. Four equally spaced elongate slots (12) are provided in the end (14) of the shank (6) remote from the head (8) and provide an expandable portion (16) of the shank, dividing this expandable end portion into four distinct

legs (17) therebetween. The base (18) of each slot (longitudinally remote from an end (14) of the shank) is axially inclined relative to an axis of the shank such that the length of the slot is longer where it is adjacent to the inner surface of the body (adjacent to the bore (20)) and is of a shorter longitudinal length where it is adjacent to the outer surface of the body.

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[0018] The mandrel (4) is of conventional design comprising a head (26) having an underhead portion (28) which increases progressively in diameter from the mandrel stem (119) towards the maximum diameter of the mandrel head (26). In this embodiment the underhead shape (28) provides a radially inclined shoulder portion. Adjacent to the shoulder portion (28) the mandrel stem has a narrowed portion (34) forming an effective recess (35) adjacent to the mandrel head.

[0019] The mandrel stem is further provided with a breakneck (36), as is conventional to blind rivets, and effectively comprises a narrowed neck portion designed to 15 break when a predetermined load is applied across this weakened region.

[0020] FIG. 2 shows the rivet assembly (10) in a set configuration when used in a particular application in a soft material. Here, the prior art peel-type blind rivet assembly (10) is used to restrain a first, relatively thin, workpiece (50) (usually of metal) onto a 20 relatively thick, considerably softer workpiece (52) which will usually be wood or plastics material. The first workpiece (50) is placed adjacent to the second workpiece (52) and a hole (54) formed therebetween, usually by a drill. The rivet assembly (10) is then inserted into the hole (54) so that the shoulder (9) of the rivet head (8) engages with the outer surface of the workpiece (50). The rivet is then set in a conventional manner of setting a blind rivet (ie. by 25 pulling the mandrel (4) downwardly as viewed in FIG. 1) while restraining displacement of the mandrel head (8) using a conventional rivet setting tool. As the rivet is set, the curved shoulder portion (28) beneath the mandrel head (26) engages with the weakened tail region

(16) of the rivet body (2) so that the separate legs (17) of the weakened region (16) are displaced outwardly from the rivet body (2) and so as to cut through and into the second workpiece (52) effectively compressing the soft material (70) which has been displaced by such cutting action.

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[0021] This prior art embodiment further includes a circumferential groove (22) which has been preformed in the rivet body so as to be adjacent to the bases (18) of the slots (12), whereby the legs (17) of the deformed rivet body tend to bend about such groove (22). Furthermore, the legs (17) themselves are further bent or curved by the radial forces applied  
10 by the radial shoulder (28) as it engages the legs during the bending or deforming operation.

[0022] As the head (26) of the mandrel (4) is displaced towards the head (8) of the rivet body (2), the setting load increases due to the increased resistance as the head approaches the groove (22) and the increased setting load serves to help collapse the groove  
15 (22) causing rivet body material adjacent to the groove (22) to be displaced inwardly into the recess (35) about the mandrel stem, thus locking the mandrel head (26) in engagement with the set rivet body. The setting load continues to increase until the rivet fails at the breakneck (36) in a conventional manner. In this embodiment the mandrel head is thus retained within  
the set rivet.

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[0023] While the prior art device performs adequately, it has been determined that the curved nature of the deformed legs (17) in the set configuration (arising from bending thereof caused by the interaction with the curved shoulder (28) of the mandrel head (26)) results  
25 from anticlastic flow of material on the inner surface of such legs as they are stretched into the curved configuration shown in FIG. 2. This results in the leg portions becoming slightly thinner than the main rivet body thickness and thus such deformed legs are thinner and weaker than the main, undeformed, region of the shank.

[0024] In addition, this prior art device comprises an additional manufacturing step in forming the indentation (22) which is able to react with the curved shoulder (28) to cause the rivet body material (72) to flow into the recess (35) to effect restraint of the mandrel head in 5 the set rivet.

[0025] It will also be understood that, as the legs of the rivet body (2) bend during setting, the inner surface of the legs tend to increase in length. Material from the rivet body to accommodate this stretching will be provided from the section of the leg at that point in a 10 movement known as anticlastic movement. This, in order to assist the movement of this material without creating undue stress, the base (18) of the slots (12) are inclined as shown in FIG. 1.

[0026] The preferred embodiment of the present invention is now shown in FIG. 3 15 and is effectively a modified version of the prior art peel-type blind rivet (10) as shown in FIG. 1 and like parts of the rivet assembly of the present invention will now be identified by the same reference numbers to those used in FIG. 1 but will include the prefix (1) or (10) for distinction.

[0027] FIG. 3 shows a modified peel-type blind rivet assembly (110) of substantially 20 similar configuration to the rivet assembly (10) and again comprises a tubular body (102) with a similar mandrel (104). The rivet body head (108), mandrel breakneck (136) and mandrel shank (106) are substantially identical to those shown in FIG. 1. Again the mandrel comprises a mandrel head (126) and the mandrel stem has a recess portion (134) adjacent to 25 this mandrel head to form a recess (135) again similar to that discussed with reference to FIG. 1.

[0028] The significant difference of the blind rivet assembly (110) resides in the shoulder portion (128) extending between the mandrel stem (119) and the maximum outer diameter (131) of the mandrel head (126). As seen in FIG. 3, this shoulder portion (128) is substantially perpendicular to the rivet axis (200) and presents a substantially flat face for  
5 flush engagement with a substantially flat end surface (114) of the rivet body (102). Formation of such a mandrel is considerably simplified to that of the mandrel (4) as seen in FIG. 1.

[0029] The second notable modification to the rivet assembly (110) is that the shank (106) is of constant diameter along its entire axial length and of constant thickness (in  
10 particular, there is no groove portion as seen in the rivet assembly (10)), thereby negating the additional manufacturing step involved in the creation of such a groove.

[0030] In addition, in the preferred embodiment of the rivet assembly of the present invention (110) shown in FIG.s 3 and FIG.s 4, the rivet body (102) has three longitudinally extending grooves (112) extending inwardly from the end (114) of the rivet body remote from the head (108) (as opposed to four in FIG. 1) and, as particularly seen in FIG. 4, these grooves (112) increase in width from an outer surface (127) of the shank (106) towards an inner surface (129) of the rivet body (102) (which surface (129) defining the rivet bore (120)). Also, as seen in FIG. 3, the assembly (110) has bases (118) of the slots (112) which are again  
20 inclined inwardly from the outer surface (127) of the body (102) towards the inner surface (129) of such body. In this manner, the slots (112) are longer adjacent to the inner surface (129) of the rivet body (102) than when adjacent to the outer surface (127) of the body (102). However, this is an optional feature and these bases (118) may in fact be flat (or substantially perpendicular to the rivet axis (200)).

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[0031] The slots (112) provide a significant advantage over the prior art slots (12) of FIG. 1 in providing for an improved manufacturing process. In particular and with reference

to FIG. 7a and 7b, a more robust metal extrusion punch (280) can be used in the formation of these slots (112) and, hence, the rivet body (102). Firstly, referring back to the rivet assembly (10) shown in FIG. 1a, it will be appreciated that the metal extrusion punch required to form the grooves (12) will comprise a cylindrical support body (to be received 5 within the bore (20) of the tubular rivet body (2)) with four perpendicular narrow cutting blades extending from this cylindrical tube for engaging the rivet body (102) to effectively cut the elongate slots (12) along such body (2) as the punch is passed through the bore (20).

[0032] Both the formation of such a extrusion punch is relatively complex due to the relatively thin projections extending therefrom, and these relatively thin projections are 10 subject to comparatively high stresses and are subject to significant wear and damage.

[0033] However, referring back to FIG. 7a, the extrusion punch (280) developed for the current invention is considerably simplified and comprises a triangular extrusion punch which, in the embodiment shown in FIG. 7a, has an axially extending location cylinder (281) 15 extending from an end face thereof. The location cylinder (281) is of corresponding size to the bore (120) of the rivet body (102) of FIG. 3 and serves to locate the punch (280) centrally of the rivet body. As such, a substantially flat end face (282) of the elongate punch (280) comprises three cutting elements (285) each formed as a convergence zone on this end face formed by the tapering convergence of two adjacent side walls of the punch. This 20 convergence zone (282) (shown as a shaded region in FIG. 7a) may be considered as the surface of the end face (282) formed between adjacent side walls of the punch (280) which, when aligned with the rivet body (102) are aligned with the shank walls so as to engage the end face (114). As shown in FIG. 7a this region is defined as the face area between the projection (281) and the dotted lines indicating the outer diameter of the shank (106). As 25 such, it will be appreciated here that while for ease of manufacturing the punch (280) is shown to have a triangular cross section, the apex of this cross section formed by the exact intersection of the side walls could be omitted since such apex does not actually engage with

the rivet body during the punch operation. However, removal of such ends would involve an additional manufacturing step and is unnecessary. What is clear, is that the cutting elements (285) are not necessarily formed in the end face at the exact apex of the converging side faces but may be set slightly back from such apex. However, it is the convergence zone of 5 the side faces which forms the appropriate cutting element.

[0034] In addition, it will be appreciated that in the embodiment shown in FIG. 7a and 7b the punch (280) is provided with a substantially flat end face (282) extending perpendicular to an axis (B) of such a punch, which will form substantially flat bases (18) of 10 the slots (112) during the slot forming operation. Alternatively, the cutting elements (285) could be inclined relative to the axis (B) of the punch (280) as shown in the alternative embodiment as shown in FIG. 7c, so as to form the inclined bases (118) of the slots (112) of the embodiment of FIG. 3. It will be further appreciated the projection (281) could, if required, be omitted and alternative alignment means between the punch (280) and rivet body 15 (102) employed.

[0035] In operation, the rivet body (102) is formed in a conventional manner following which the extrusion punch (280) is engaged with the free end (114) thereof so as to form the slots (112) as shown in FIG. 4. This improved punch (280) is more readily 20 manufactured as a simple polygonal shape providing for greater strength since its cutting elements are considerably larger and more robust than those utilised in the prior art. Since this punch is more robust and easier to manufacture, it results in a reduction in production costs of such tools and is less prone to wear and failure.

25 [0036] Referring now to FIG. 5, showing the rivet assembly (110) in its set configuration, the manner of setting the rivet (110) is substantially identical to that of rivet assembly (10), whereby again the mandrel (104) is engaged by a rivet setting tool and

displaced relative to the rivet body (106) once the rivet assembly (110) has been inserted in a preformed hole (154). However, the specific performance of the improved rivet assembly (110) will now be described.

5 [0037] As a setting load is applied (in a direction illustrated by arrow (F) in FIG. 3) a compressive load is exerted by the flat shoulder (128) of the mandrel head (126) onto the corresponding flat end (114) of the rivet body, causing the legs (117) (defined between the array of slots (112)) to resiliently deform and to be splayed radially outward of the body (102) until the shoulder (128) engages with the inner surface (127) of these splayed legs 10 (117). In this manner, there is now a linear displacement force created by linear engagement of the linear (non-curved) shoulder (128) with this inner surface (127) so that the legs are displaced in a cantilever manner about their engagement portion (157) with the main part of the shank (106). Here, the legs (117) are not themselves bent during this setting operation 15 but are maintained in their original straight configuration and thus do not undergo any stretching or anticlastic deformation. In this way the set legs shown in FIG. 5 are considerably stronger than those shown for the prior art embodiment shown in FIG. 2, while the legs (117) themselves are still splayed so as to cut through the softer workpiece (normally wood) (52) in a similar manner to that shown in FIG. 2 to compress the material between these legs and the outer workpiece (150). These non-deformed legs (117) retain their 20 original thickness following setting and not being curved, so as to be stronger than those of the prior art and, as seen in FIG. 5, which could be prone to deformation if a pull out force is applied to the set rivet.

[0038] As the mandrel head (126) is again displaced further into the rivet body (106) 25 towards the head (108), the setting load increases due to the increased resistance incurred by the mandrel head (126) towards the end (118) of the slots (112), due to the main shank (106) of the body (102) being resistant to radial deformation since it does not have slots (112)

extending therethrough. As this setting load increases, the substantially flat shoulder (128) of the mandrel head (126) is no longer able to apply a radial displacement force to the legs (117) and thus effects a compressive force on the rivet body (in direction F) causing flow of the rivet body material into the recess portion (135) formed about the narrowed section (136) 5 of the mandrel stem to again effect engagement between the mandrel head and the rivet body in the set position. Increased loading force on the mandrel will then result in the mandrel failing at the breakneck (136) in a conventional manner. This modified assembly (110) provides additional strength in comparison to the prior art resulting from the cantilevered displacement of the performed legs (117) during the setting operation, thereby maintaining 10 the thickness of the leg sections to be the same as the thickness of the main rivet body wall following the setting operation, providing greater sectional strength.

[0039] While this preferred embodiment shown in FIG.s 3 to 5 has utilised the formation of three slots (112) to form three corresponding legs (117) of equal size (such slots 15 being displaced at equal angles about the axis of the rivet), it will be appreciated that alternative numbers of legs and associated slots could be employed. If four slots were required to form four legs, then a substantially square punch could be employed, utilising the invention as discussed with relation to the setting tool (280) shown in FIG. 7. If required, higher polygonal numbers could also be employed by using punches having hexagonal or 20 higher order cross sectional configurations. In addition, while the punch design according to the present invention comprises regular polygons as shown in FIG. 7, the side faces of such punches need not be straight but could be curved to produce curved side walls of slots (212) within the rivet body (202), as shown in the alternative embodiment in FIG. 6 which have been formed by a substantially concave triangular punch to produce convex edges to the 25 tapered slots (212) in such embodiment.